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Introduction

Pumpkins for decorative use are grown on more than 4000 acres in Indiana. Combined acreage in Indiana, Michigan, Illinois, and Ohio represents about a quarter of pumpkins grown for decorative use in the U.S. Successful pumpkin production requires the use of cultivars that yield well and produce pumpkins of the size, shape, color, and quality demanded by the market. Genetic resistance to the fungal disease powdery mildew is present in some varieties. This trial was designed to evaluate performance of pumpkin varieties in northern Indiana with and without treatment for powdery mildew. The trial included twelve jack-o-lantern size pumpkins, two small or pie pumpkins, and one mini-pumpkin. Also reported are yield and fruit characteristics for seven additional varieties grown in unreplicated plots.

Materials and Methods

The trial was conducted at the Pinney-Purdue Agricultural Center in Wanatah, Indiana. Treatments were arranged in a split plot design with powdery mildew treatment (yes or no) as the main plot, and variety as the subplot. Treatments were replicated three times in blocks. Subplots were 36 feet long by 21 feet wide. Main plots were 105 feet wide and included three tiers of five subplots each, separated by 15-foot alleys.

The soil was a Tracy sandy loam with 1.5% organic matter and 32 ppm phosphorus (P), 92 ppm potassium (K), 155 ppm magnesium (Mg), 600 ppm calcium (Ca), and pH 6.2. The prior crop was soybeans (in 2007) followed by a cover crop of winter wheat. A total of 80 lb./A N was applied; half from urea broadcast on May 7, and the remainder from urea ammonium nitrate injected on July 14. Pumpkins were planted on June 12 using a modified John Deere Maximerge 7000 planter and dropping seeds by hand into the seed tube. Each pumpkin cultivar was planted in six subplots 36 feet long and 21 feet wide with two rows spaced 7 feet 4 inches apart. Weeds were controlled with the preemergence herbicide Strategy® (ethalfluralin+clomazone), which was applied at 4 oz./A on June 12, and by cultivation, hoeing, and hand weeding. Overhead irrigation was applied on June 16 to incorporate herbicide and during the season as needed. Pumpkins were thinned to achieve the desired stand of 24 plants per plot for jack-o-lantern pumpkins (1383 plants/A), and 48 plants per plot for pie and mini-pumpkins (2766 plants/A). The insecticide Arctic® 3.2 EC was applied at 4 oz./A on July 18, July 24, and August 1 for squash vine borer; and Mustang® was applied at 4 oz./A on August 29 for squash bug. Main plots assigned to receive treatment for powdery mildew were treated as follows: Topsin M® at 0.5 lb./A and Bravo Ultrex® at 1.4 lb./A. on July 18 and August 15; Nova® at 2.5-4 oz./A and Bravo Ultrex® at 1.4 lb./A on August 1 and 22. All plots were protected against downy mildew with applications of Previcur Flex® at 1.2 pt./A on July 11, August 15, and August 29; and Ranman® at 2.1 oz./A on July 18, August 1, and August 22. Downy mildew did not appear in the area until the end of September.

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Powdery mildew severity was evaluated on August 30 by estimating percent leaf surface covered with powdery mildew on upper and lower surfaces of two young, two middle-aged, and two old leaves per plot. Leaves were evaluated and recorded using the Horsfall-Barratt scale, and the overall severity of disease was rated on a scale from 9 (no disease) to 1 (extremely severe disease). Plant vigor was also rated using a scale of 9 (extremely vigorous) to 1 (very low vigor). On October 13, the percent of foliage still green was estimated (data not shown). Pumpkins were harvested September 3-8 and October 3. Harvested fruit were graded into marketable orange (rind at least one-half orange), marketable green (full size and starting to turn but less than one-half orange), and cull. Number and weight of pumpkins in each group were recorded and used to calculate average fruit size and percent of total yield in each category. On September 11, pumpkins from one replication were evaluated for color, shape, suture depth, peduncle length and width, uniformity, and overall quality. On this date and on October 6 peduncle health was rated for five orange pumpkins per plot, using a scale of 5(solid throughout length) to 1 (collapsed and disintegrating over half the length).

Yield and yield components were analyzed separately for jack-o-lanterns, pie pumpkins, and the mini-pumpkin. Disease and vine vigor were analyzed for all varieties combined. Analyses of variance were used to test for main effects and interactions when appropriate, followed by mean separation using Fisher's protected least significant difference. Horsfall-Barratt ratings were converted to percentages and then transformed to stabilize variances before analysis. Means of untransformed percentages are presented. Peduncle ratings did not meet assumptions for analysis of variance, so treatment means and standard errors are presented.

In an area adjacent to the replicated trial, seven varieties were planted in single plots as an observation trial. They were seeded on June 17 and managed similarly to the replicated trial, with all plots receiving fungicide applications for powdery mildew.

Results and Discussion

The growing season was cool and dry until September, except for a 5.2-inch rain in early August. Temperatures averaged 1.7, 1.8, and 2.3 degrees below normal for June 12-30, July, and August, respectively, and growing degree days for the period were 151 below normal. September averaged 0.8 degrees above normal, and rainfall totaled more than 12 inches, most falling in a three-day period the second week of September.

Powdery Mildew Severity and Vine Vigor

Powdery mildew leaf coverage on August 30 averaged 10% in plots that received fungicide treatments and 44% in plots that did not (Table 1). Varieties differed in resistance to powdery mildew, with more differences apparent in untreated plots, although rankings of the varieties were generally similar in treated and untreated plots. In treated plots, Camaro and HSR 4710 had the lowest amount of powdery mildew at 1%, but did not have significantly less than Gladiator, Warlock, Magic Wand, HSR 4721, Gold Speck, or HSR 4709. In untreated plots, Camaro, Warlock and Gladiator had the least amount of powdery mildew at 11%, but did not differ significantly from HSR 4721 or HSR 4710. In the treated plots, varieties showing intermediate resistance included Magic Lantern and Fall Splendor, which had more disease (10%-11%) than Camaro and HSR 4710, but significantly less than Gold Medal and Solid Gold (28%). In untreated plots, varieties showing intermediate resistance included Magic Wand and Gold Speck, both with significantly more disease than Camaro, and less than Magic Lantern. In untreated

plots, Magic Lantern and Earlipak (51%-53%) had significantly less disease than Solid Gold, Gold Challenger, Prankster, and Gold Medal (70%-88%). Overall powdery mildew severity ratings averaged 6.5 in treated plots and 4.7 in untreated plots.

Vine vigor, which was evaluated on August 30, was not significantly influenced by powdery mildew treatment, averaging 6.3 in treated plots and 5.9 in untreated plots. Varieties that ranked highest for vine vigor included Gold Medal and Camaro, although they were not significantly different from most others in the trial. Varieties with smaller vines included Fall Splendor, HSR 4721, and Earlipak.

Yield, Number of Fruit, and Fruit Size

Jack-o-lantern pumpkins averaged 19.4 tons per acre of marketable orange fruit in treated plots and 8.2% less, or 17.8 tons per acre, in untreated plots; the difference was marginally significant ($P<0.10$) (Table 2). The number of marketable orange fruit averaged 2116 per acre and 2025 per acre (4.3% less) for treated and untreated plots, respectively, with no significant difference. Average weight per pumpkin was 18.8 pounds in treated plots and 18.1 pounds in untreated plots, but did not differ significantly. Yield of orange plus green pumpkins was significantly greater in treated plots than in untreated plots (22.0 tons versus 19.0 tons per acre). Similar results were observed for the pie and mini-pumpkin varieties: yield in tons and number per acre tended to be greater in treated plots, and differences were more likely to be significant for tons than for number per acre and for orange plus green fruit than for just orange fruit. If September and October harvests and are considered separately, it is clear that treatment for powdery mildew had little effect on yield or fruit size in the September harvest; had a greater effect on weight, number, and fruit size of orange pumpkins in the second harvest; and had the largest impact on weight and number of green pumpkins in the second harvest (data not shown). It appears that in this trial, powdery mildew was not severe enough to negatively influence set and development of the first fruit.

Table 2 presents variety means for treated and untreated plots separately, but the following discussion of yield and fruit size differences among varieties is based on the average of treated and untreated plots for each variety because there was no significant interaction between powdery mildew treatment and variety.

The jack-o-lantern pumpkins fell into three groups based on average fruit weight. Seven varieties produced orange fruit averaging 18 to 23 pounds: HSR 4710 (22.9 lb.), Gold Medal (22.3 lb.), HSR 4709 (21.1 lb.), Earlipak (21.1 lb.), Solid Gold (20.3 lb.), Camaro (20.2 lb.), and Warlock (18.8 lb.). For these seven varieties, yield of orange pumpkins ranged from 17.2 to 24.5 tons and 1719 to 2526 fruit per acre. Camaro produced the highest yield of orange pumpkins in tons and number per acre, followed by HSR 4710 which was not significantly lower. HSR 4709 produced tons per acre similar to HSR 4710, and significantly greater than others in this group. Both HSR 4709 and Warlock produced numbers of fruit similar to HSR 4710, and significantly more than Gold Medal, Solid Gold, and Earlipak. Camaro seems to be heavy for its size and Warlock seems to be light for its size.

Four jack-o-lanterns produced orange fruit averaging 14 to 17 pounds: Magic Wand (16.7 lb.), Gladiator (16.6. lb.), Gold Challenger (15.8 lb.), and Magic Lantern (14.4 lb.). For these four varieties, yield of orange pumpkins ranged from 14.8 to 17.5 tons and 1719 to 2640 fruit per acre. Of these four varieties, Magic Lantern, Magic Wand, and Gladiator produced similar numbers of orange pumpkins per acre, significantly more than Gold Challenger. Magic Wand

produced the highest yield of orange fruit in tons per acre, but not significantly more than Magic Lantern. Gladiator and Gold Challenger produced similar tons per acre, and Gladiator was not significantly different from Magic Lantern. Gladiator was later than other varieties in this group: 23% of all fruit produced was still green at the second harvest, compared to 4% to 13% for other varieties in this size group (data not shown).

HSR 4721 produced the smallest fruit of the jack-o-lantern types at 11.2 pounds, but the greatest number of orange fruit at 3659 per acre and yield in the middle of the range at 17.5 tons per acre.

The two pie pumpkins were inadvertently grown at different plant populations so yield comparisons are not valid. Average orange fruit weight was 4.5 pounds for Fall Splendor and 3.3 pounds for Prankster. The mini-pumpkin Gold Speck produced 0.4-pound fruit, averaging 30,423 fruit and 5.9 tons per acre.

Fruit Quality

Observations on fruit shape, color, peduncle length and width, fruit uniformity, and overall fruit appearance are shown in Table 3. Varieties that received above average ratings for fruit uniformity included Camaro, Earlipak, Magic Wand, Magic Lantern, HSR 4721, Fall Splendor, Prankster, and Gold Speck. Varieties with overall appearance ratings above average included Earlipak, Solid Gold, Magic Wand, Magic Lantern, Gladiator, Gold Challenger, Fall Splendor, Prankster, and Gold Speck. Varieties that received peduncle health ratings higher than average in both treated and untreated plots and for both first and second harvests included Gold Medal, Gold Challenger, Warlock, Gladiator, Magic Wand, Fall Splendor, and Gold Speck (Table 1). Varieties that consistently received peduncle health ratings below average included HSR 4709, Magic Lantern, and Earlipak.

Observation Trial

Results from the unreplicated plots are presented in Tables 2 and 3. Four pie pumpkins were included. Cannonball and Field Trip both produced pumpkins averaging 5 pounds. Cannonball fruit were round and Field Trip fruit were squat with a long stem. Iron Man and Gargoyle produced 4.2- and 4.0-pound fruit, respectively. Gargoyle fruit has occasional warts. Iron Man matured fairly late, with only 18% of all fruit orange by the first harvest. For both Gargoyle and Iron Man, a quarter of the total yield was still green at the second harvest in early October. Galaxy of Stars is a multicolored gourd mix producing 0.3-pound fruit in variations of the Crown of Thorns shape. Colors include orange, cream and green stripes, and sections. SSX 5122 is an oblong jack-o-lantern pumpkin averaging 26.8 pounds that looked promising. Small World of Color Mix is a *Cucurbita maxima* mix averaging 15.2 pounds, with a variety of colors (including deep orange-red, blue-gray, salmon, cream, and orange-yellow), shapes (from squat to oblong), and surfaces (from smooth to rough). The variety of color and shape makes it an excellent candidate for use in many fall decorations.

Summary

Several varieties with acceptable yield and fruit quality show little powdery mildew even when not treated with fungicides to protect against the disease. Magic Wand and Gladiator were the most similar in size and color to the widely-grown Magic Lantern, but showed better disease resistance and peduncle quality. Camaro stood out with good disease resistance and high yield; compared to Magic Lantern it is larger and lighter in color. Warlock, also larger than Magic

Lantern, also showed good disease resistance and is dark orange; it tends to produce some irregular shapes and the rind is rough and hard, which may reduce suitability for certain markets. Producers are encouraged to evaluate powdery mildew resistant varieties in their operations and adopt those that perform well.

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Table 1. Powdery mildew severity, vine vigor, and peduncle health for pumpkin varieties grown with (Yes) and without (No) fungicide treatment to protect from powdery mildew, Wanatah, Indiana 2008[z].

Variety	Percent Powdery Mildew[Y]		Overall Powdery Mildew Rating[X]		Vine Vigor Rating[X]		Peduncle Health[W]			
							September 17		October 6	
	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Gold Medal	70 b	28 ef	2.7	5.3	8.0	7.7	4.9 ± 0.13	4.9 ± 0.13	4.4 ± 0.42	4.8 ± 0.15
Solid Gold	88 a	28 ef	1.7	4.7	5.7	7.3	4.2 ± 0.46	4.5 ± 0.27	2.2 ± 0.56	4.1 ± 0.13
Gold Challenger	78 ab	24 fg	2.3	5.3	7.3	6.7	4.3 ± 0.13	4.9 ± 0.07	4.3 ± 0.13	5.0 ± 0.00
Camaro	11 g	1 m	8.0	8.3	8.3	7.7	3.7 ± 0.13	3.4 ± 0.20	4.4 ± 0.23	4.7 ± 0.13
HSR 4709	46 de	8 ijklm	4.3	6.3	5.3	6.7	3.3 ± 0.13	3.3 ± 0.29	3.6 ± 0.12	3.9 ± 0.29
HSR 4710	22 fg	1 m	6.7	7.0	6.7	6.7	3.5 ± 0.29	3.4 ± 0.20	4.1 ± 0.13	4.6 ± 0.20
HSR 4721	20 fg	4 klm	6.3	7.3	3.7	5.0	3.6 ± 0.46	4.4 ± 0.20	4.7 ± 0.18	4.8 ± 0.12
Warlock	11 g	3 klm	6.7	7.7	6.3	6.0	4.4 ± 0.12	4.5 ± 0.18	4.9 ± 0.07	4.9 ± 0.13
Gladiator	11 g	2 lm	7.0	7.7	6.0	6.0	4.3 ± 0.29	4.2 ± 0.20	4.7 ± 0.24	4.7 ± 0.22
Magic Wand	28 ef	4 klm	6.3	7.7	7.0	7.3	4.6 ± 0.23	4.6 ± 0.12	4.8 ± 0.20	5.0 ± 0.00
Magic Lantern	51 cd	10 hijkl	3.7	6.3	5.3	6.7	3.8 ± 0.42	4.2 ± 0.12	3.9 ± 0.58	4.1 ± 0.54
Earlipak	53 cd	15 fghi	3.3	5.7	5.0	4.7	3.3 ± 0.24	3.5 ± 0.13	3.1 ± 0.44	4.5 ± 0.24
Fall Splendor	65 bc	11 ghijk	3.0	5.7	1.7	3.3	4.6 ± 0.12	5.0 ± 0.00	4.4 ± 0.35	4.9 ± 0.07
Prankster	77 ab	14 fghij	3.0	4.7	5.7	5.3	4.9 ± 0.13	4.7 ± 0.18	3.6 ± 0.43	4.9 ± 0.07
Gold Speck	27 f	5 jklm	5.7	7.3	7.0	7.0	5.0 ± 0.00	5.0 ± 0.00	4.7 ± 0.18	4.9 ± 0.07
Average	*44**	*10*	*4.7***	*6.5*	*5.9*	*6.3*	*4.2*	*4.3*	*4.1*	*4.6*
LSD .05[v]			*1.1*	*1.1*	*1.7*	*1.7*				

[z]Values are means of three replications. * and ** indicate significant difference between mean of treated and untreated plots at $P \leq .05$ and .01, respectively.

[y]Percentage of leaf surface covered with powdery mildew on August 30 based on two young, two middle-aged, and two old leaves per plot. Means within a column followed by the same letter do not differ significantly at $P \leq .05$ according to Fisher's protected LSD.

[x]Overall powdery mldew severity in each plot rated August 30on a scale of 1-9, with 1=extremely severe powdery mildew and 9=no powdery mildew. Vine vigor rated on August 30 using a 1-9 scale, with 1=very low vigor and 9=extremely high vigor.

[w]Peduncle health rating for five orange fruit per plot on September 11 and October 6 using a 1 to 5 scale, with 5=peduncle solid throughout length; 4=peduncle pliable up to a third of its length; 3=peduncle pliable for more than than half its length, but not shriveled; 2=peduncle pliable and shriveled for most of its length; 1=peduncle collapsed and disintegrating over most of length. Mean ± standard error.

[v]Means within a column differing by more than this amount are significantly different at $P \leq .05$ according to Fisher's protected LSD.

Table 2. Average fruit weight, number of fruit, and yield of pumpkin varieties grown with (Yes) and without (No) fungicide treatment to protect from powdery mildew, Wanatah, Indiana 2008[z].

Variety	Seed Source[y]	Stand *Plants/A*	Marketable Orange Fruit[x]						Marketable Orange and Green Fruit[x]			
			No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
			Lb./frt.		*No./A*		*Tons/A*		*No./A*		*Tons/A*	
Jack-o-lanterns												
Camaro	HL	1229	19.3	21.1	2497	2362	24.0	25.0	2650	2401	25.3	25.3
Earlipak	SK	1383	21.3	20.8	1575	1690	16.8	17.6	1594	1844	16.9	18.6
Gladiator	HM	1383	16.4	16.8	1729	1921	14.1	15.9	2190	2574	17.5	21.2
Gold Challenger	RU	1373	15.5	16.1	1882	1863	14.6	15.0	1921	2017	14.8	16.1
Gold Medal	RU	1383	22.4	22.3	1652	1825	18.5	20.3	1652	2055	18.5	22.2
HSR 4709	HL	1383	19.6	22.6	2036	2132	19.7	24.1	2074	2324	20.1	25.9
HSR 4710	HL	1383	23.2	22.6	1844	2132	21.3	24.0	2074	2574	23.4	29.2
HSR 4721	HL	1316	10.7	11.6	2958	3323	15.8	19.1	3342	3976	18.1	23.3
Magic Lantern	HM	1383	14.5	14.2	2382	2401	17.3	17.1	2497	2785	18.0	19.9
Magic Wand	HM	1383	16.1	17.4	2170	2017	17.4	17.5	2343	2535	18.4	21.3
Solid Gold	RU	1383	19.7	20.8	1594	1901	15.7	19.8	1594	1959	15.7	20.2
Warlock	HM	1383	18.7	18.9	1978	1825	18.5	17.2	2228	2190	20.8	21.2
Average			*18.1*	*18.8*	*2025*	*2116*	*17.8†*	*19.4*	*2180*	*2436*	*19.0**	*22.0*
LSD .05[w]			*2.6*	*2.6*	*321*	*321*	*3.1*	*3.1*	*400*	*400*	*4.3*	*4.3*
Pie Pumpkins												
Fall Splendor	HM	1383	4.4	4.7	3995	4110	8.7	9.6	4053	4417	8.8	10.4
Prankster	RU	2766	3.3	3.2	5397	6453	8.9	10.4	5416	6492	8.9	10.4
Average			*3.8*	*4.0*	*4696*	*5282*	*8.8†*	*10.0*	*4734†*	*5455*	*8.9**	*10.4*
Mini-pumpkin												
Gold Speck	RU	2103	0.41	0.38	24546 †	36300	4.9*	6.9	(no green fruit)			
Observation Trial												
Cannonball	HM	1268	–	5.0	–	3688	–	9.2	–	4264	–	10.4
Field Trip	HM	1383	–	5.0	–	5359	–	13.3	–	5359	–	13.3
Galaxy of Stars	RU	1383	–	0.3	–	47709	–	7.9	–	47709	–	7.9
Gargoyle	HM	1383	–	4.0	–	3976	–	8.0	–	5128	–	10.5
Iron Man	HM	1383	–	4.2	–	4379	–	9.2	–	5877	–	12.4
Small World of Color Mix	RU	1383	–	14.6	–	2305	–	16.9	–	2305	–	16.9
SSX 5122	SK	1152	–	26.8	–	1498	–	20.1	–	1901	–	24.5

[z]Values are means of three replications, except for observation trial, which was unreplicated. † and * indicate significant difference between mean of treated and untreated plots at $P \leq .10$ and .05, respectively. – no data.

[y]HM=Harris Moran, HL=Hollar, RU=Rupp, SK=Sakata.

[x]Marketable orange fruit includes all firm fruit at least one-half orange. Marketable orange and green includes all firm fruit of mature size and starting to turn orange by October 6.

[w]Jack-o-lantern variety means within a column differing by more than this amount are significantly different at $P \leq .05$ according to Fisher's protected LSD.

Table 3. Fruit characteristics of pumpkins grown in Wanatah, Indiana 2008.[z]

Variety	Color[w]	Shape[w]	Sutures[w]	Peduncle [w]		Uniform[w]	Overall[w]
				Length	Width		
Replicated Trial							
Camaro	L	R	S	5.0	4.0	6.5	5.5
Earlipak	M-D	S	M	6.5	4.5	7.0	7.0
Fall Splendor	M	R	M	5.5	5.5	6.5	7.5
Gladiator	D	R	M	5.5	5.5	6.0	6.0
Gold Medal	M	S-T	M	4.5	6.5	3.0	4.5
Gold Challenger	D	R-O	M-D	6.5	5.5	6.0	6.0
Gold Speck	L	S	D	8.0	2.0	7.0	7.0
HSR 4709	L	V	S-D	4.0	4.5	4.0	4.0
HSR 4710	L	R-O	M	4.0	4.5	6.0	5.0
HSR 4721	L	R-O	S	5.5	5.0	6.5	4.5
Magic Lantern	D	R	S-M	4.5	4.0	6.5	6.5
Magic Wand	M-D	S-R	M-D	5.0	5.0	7.0	7.0
Prankster	M	S	M	4.0	6.5	7.0	6.0
Solid Gold	M	R-O	S	7.0	6.5	6.0	6.5
Warlock	D	S-O	S-D	4.0	6.0	5.0	5.5
Observation Trial							
Cannon Ball1626	D	R	M	5	6	8	8
Field Trip	M	S	M-D	9	5	7	8
Galaxy of Stars	MT	V	V	9	2	2	8
Gargoyle	M	R	M	6	6	7	7
Iron Man	M	R	M	5	6	7	7
Small World of Color Mix	MT	S-O	S-M	3	2	1	8
SSX 5122	D	O	M	5	6	7	8

[z]Observations for replicated trial made on September 11 from one plot not treated for powdery mildew and one plot treated for powdery mildew, otherwise one plot per variety.

[w]Fruit color: D=dark, M=medium, L=light orange, MT=multi-colored. Shape: S=squat, R=round, O=oblong, V=variable. Sutures: S=shallow, M=medium, D=deep. Peduncle length and width, fruit uniformity, and overall fruit quality rated on a 1-9 scale, with 2=short/thin/ peduncle, non-uniform, poor quality; 5=average; 8=extra long/extra thick/dark green solid peduncle, very uniform, high quality.